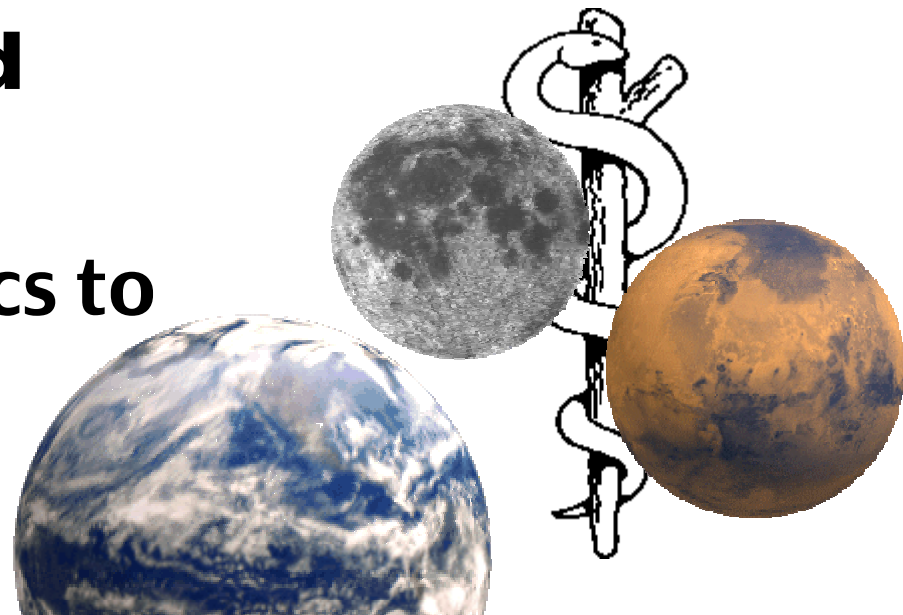




Health Care Needs for LEO and Beyond

The Application of Medical Informatics to Space Flight



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Associate Administrator

NASA Office of Life & Microgravity Sciences & Applications



Agency & Enterprise Goals

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Agency Mission

Advance & communicate scientific knowledge & understanding of the Earth, the solar system, & the universe & use the environment of space for research

Explore, use, & enable the development of space for human enterprise

Research, develop, verify, & transfer advanced aeronautics, space, & related technologies

long
term

near
term

long
term

HEDS Goals

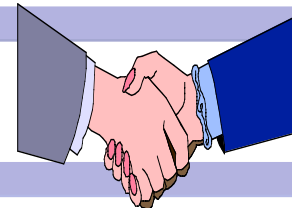
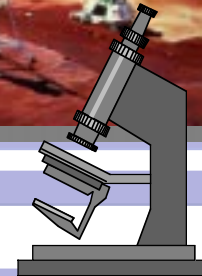
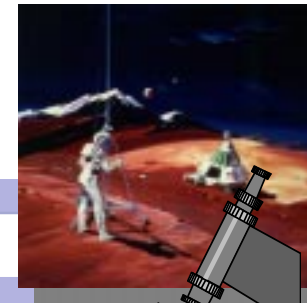
Expand the frontier

Expand knowledge

Enable and establish permanent and productive human presence in Earth orbit

Expand commercial utilization of space

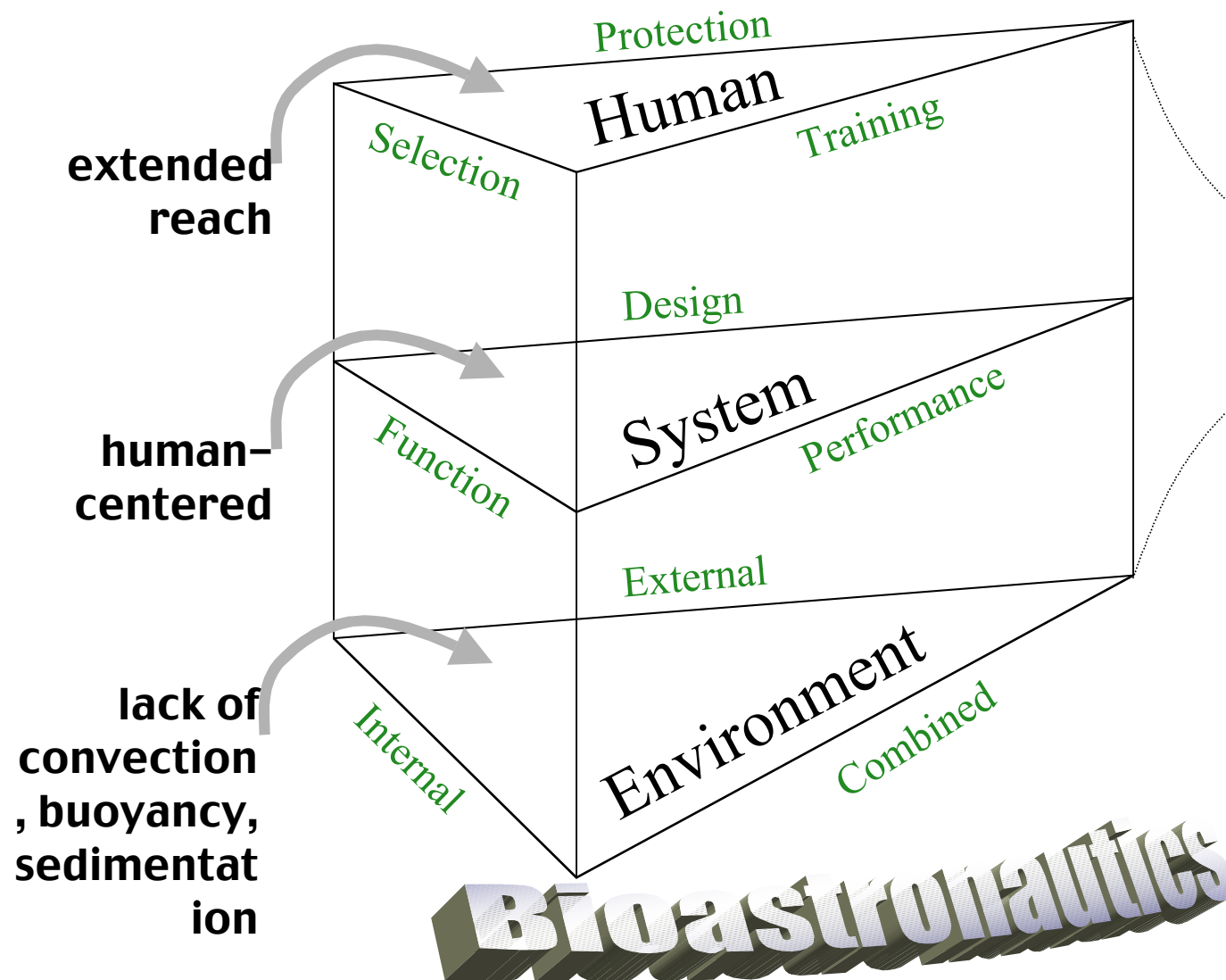
Share the experience and discovery of human space flight





Elements of Human Space Mission Design

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Exploration



Establishment of Medical Policy

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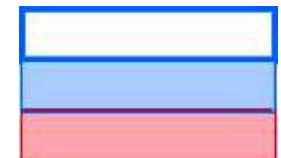
National

- ❑ *Medical Policy Board* at NASA Headquarters
- ❑ *Occupational Health and Safety Executive Board* at NASA HQ
- ❑ *Aerospace Medicine Board* at NASA JSC
- ❑ *Institutional Review Board*
- ❑ *Animal Care and Use Committee*
- ❑ *Bioethics group* chaired by Dr. Baruch Brody of Baylor College of Medicine
- ❑ Astronaut *longitudinal studies*



International

- ❑ *Multilateral Medical Policy Board*
- ❑ *Multilateral Space Medicine Board/Working Group*
- ❑ *Multilateral Institutional Review Board*
- ❑ *Multilateral Animal Care and Use Committee*





Medical Care Criteria



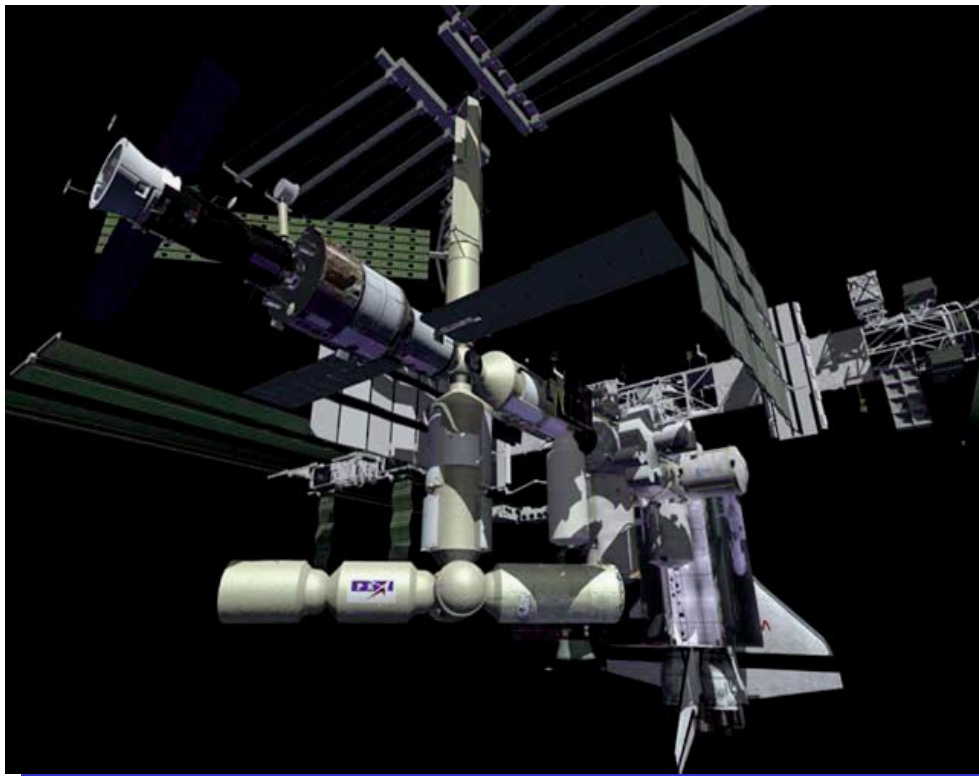
- ❑ Be able to
 - *Treat crew members for a wide range of illness, injury, or psychosocial matters*
 - *Return them to effective duty*
- ❑ Maximize the chance of mission completion & successful elective return
- ❑ Minimize the impact of a crew member's illness or injury on any other crew member
- ❑ Provide for
 - *Stabilization and timely evacuation of a sick crew member to a definitive care facility*
 - *Stabilization and timely evacuation without affecting the safety of remaining crew*
 - *Timely consultation via telemedicine*



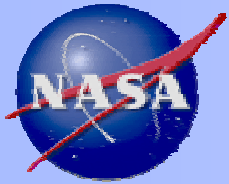
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- Ability to function as a productive member of the flight crew and perform assigned duties



- Ability to maintain adequate orthostatic tolerance during de-orbit & landing
- Ability to execute (rapid &) unaided egress from the spacecraft



An In-flight Health Model

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microgravity

Adaptation

- ❑ Red blood cell loss
- ❑ Fluid loss
- ❑ Cardiovascular adjustment
- ❑ Changes in neural control (blood pressure)
- ❑ Decreased receptor sensitivity?

*hypo-volemic
syndrome*

Pathophysiology

- ❑ Radiation
- ❑ Bone & muscle loss
- ❑ Closed environment
 - *life support*
 - *psycho/social/cultural*
- ❑ Immunology
- ❑ Metabolism

degenerative diseases



A Post-flight Health Model

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return to gravity

- ❑ Neurosensory motor control dysfunction
- ❑ Diminished cardiovascular reserve
- ❑ Decreased immune response
- ❑ Dehydration

*cardiovascular
& neurological
compromise*

- ❑ Regional osteopenia
- ❑ Decreased muscle endurance & strength
- ❑ Increased risk of kidney stone(s)
- ❑ Radiation career dose exposure

health risks



Space Flight Medical Events

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Adaptive

- ❑ Space Motion Sickness - 30%
- ❑ Bone loss - 1%/month after 1st month
- ❑ Muscle strength deterioration - 1%/week to max of 30%
- ❑ Head and neck congestion - 80%
- ❑ Sleep difficulty - 50%




Illness/injury

- ❑ Headaches - 60%
- ❑ Kidney stone(s) - <1%
- ❑ Skin disorders - 15%
- ❑ Urinary retention - 1%
- ❑ Retinal hemorrhage - <1%
- ❑ Cardiac dysrhythmias - 2%
- ❑ Orthostatic intolerance - 20%



A Shift Toward Primary Prevention

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-  *primary prevention*
-  *secondary prevention*
-  *tertiary prevention*

Pre flight	Preventive Health Screening/Countermeasures	Preventive Health Screening/Improved Countermeasures	Preventive Health Screening/Advanced Countermeasures
In flight	Limited Countermeasures & Intensive Monitoring	Improved Countermeasures & Intensive Monitoring	Effective Countermeasures/monitoring
Post flight	Medical Care & Intensive Rehab	Rehabilitation	Health Maintenance
	1999	2006	2010



Current In-flight Medical Capabilities

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- ❑ Space Shuttle
 - *Medical kit flown on each flight*
 - *Defibrillator flown when appropriate (based upon flight requirements and payload complement)*
 - *At least 1 crew member trained to deliver basic primary care should the need arise*
 - *When a physician flies, he/she assumes crew medical officer role*
- ❑ International Space Station
 - *Crew Health Care System (CHeCS)*
 - multipurpose medical station for astronaut health maintenance
 - countermeasures station
 - environmental monitoring
 - *“Ambulance” or “lifeboat” capability in development with the Crew Return Vehicle*
- ❑ ***Beyond LEO?***





Health Care Needs Beyond LEO

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*The remoteness of exploration-class missions
generates a unique set of requirement for
health care systems*

- ❑ Compact
- ❑ Lightweight
- ❑ Portable
- ❑ Low maintenance
- ❑ Easy-to-use
- ❑ Autonomous
- ❑ Minimally invasive

*Medical informatics is
the cross-cutting
technology*

- ❑ Interface capability
- ❑ Presentational/display versatility
- ❑ Flexibility
- ❑ Computational power



Telemedicine

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*Telemedicine address
health care needs in space
by conquering **time** and
distance*

- ❑ Training
- ❑ Data Collection
- ❑ Trend analysis
- ❑ Health maintenance
planning and execution
- ❑ Diagnostic support
- ❑ Consultations

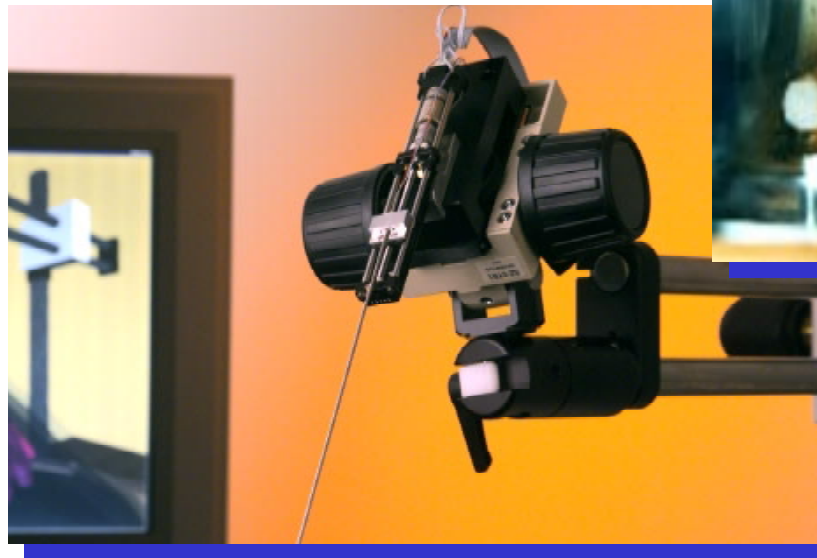




Trend: Haptic “Smart” Systems

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- ❑ Cybersurgery
- ❑ Microsurgical probes
- ❑ Tissue engineering



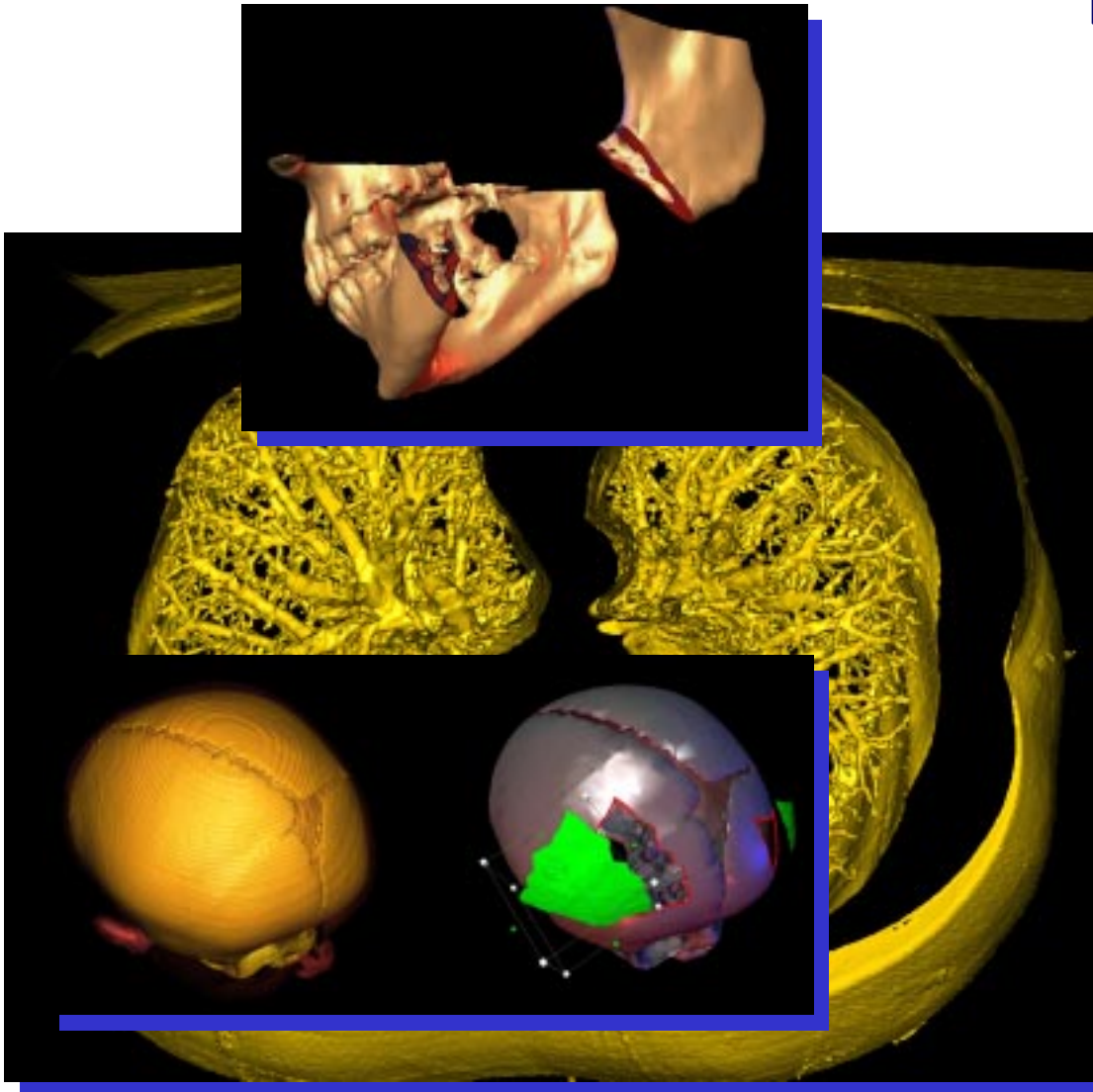


Trend: Virtual Reality

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□ Biocomputation

- *improved skills*
- *pre-surgery planning*
- *new techniques testing*
- *immersive robotic surgery*

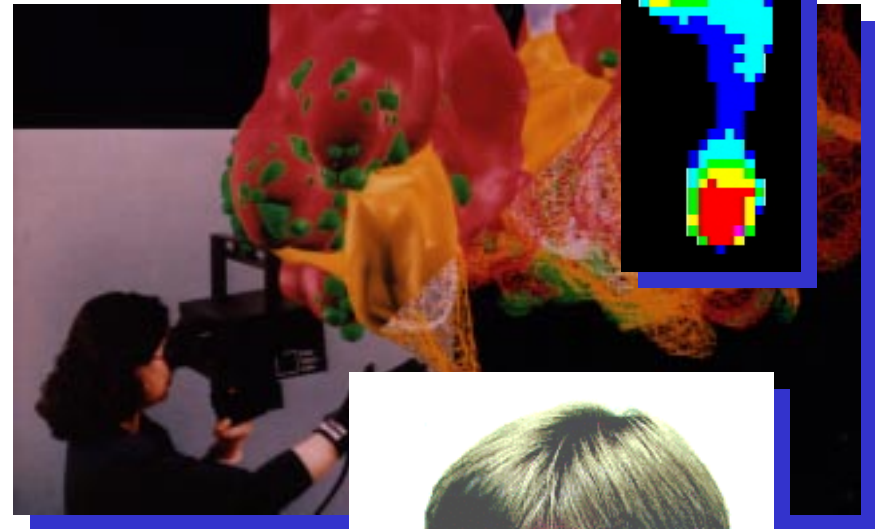


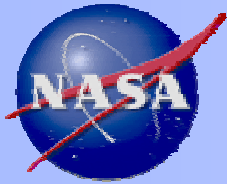


Trend: Portability

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- ❑ Sensors
 - “*smart*” T-shirts
 - “*smart*” suits
 - *force interface*
- ❑ Biochemical probes
- ❑ Immersive technologies
- ❑ Innovative displays
 - “*heads-up*” display
(*Wireless Augmented Reality Prototype, WARP*)





Trend: Biologically-inspired Technologies (funded)

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Robotics

- ❑ Biologically-inspired robots
- ❑ Artificial trunks, tentacles, worms, snakes, and whiskers
- ❑ manipulation and locomotion

Human-centered Systems

- ❑ Adaptive automation
- ❑ Multipurpose tactile interface
- ❑ Maintaining spacecraft operator alertness
- ❑ Performance measurement, evaluation, and modeling
- ❑ Non-invasive video motion capture of astronaut activity
- ❑ Cognitive prostheses

Smart Materials and Structures

- ❑ Self-assembled hard nanocomposite coatings
- ❑ Hollow helix as nanotube
- ❑ Artificial spider as drag-line silk
- ❑ Motor proteins as molecular cargo
- ❑ Artificial hair cells and sensors
- ❑ Functionally-adaptive biomimetics
- ❑ Artificial neural device
- ❑ Wireless biosensors

